with arithmetic mean (UPGMA) or average distance trees (Sneath and Sokal 1973) were calculated using NEIGHBOR in PHYLIP. Bootstrap results for assessing the frequency of occurrence, and thus significance, of each tree cluster were attained using SEQBOOT and CONSENSE in PHYLIP with 1000 replicates. Trees were visualized using TREEVIEW (Page 1996).

Results

None of the nine Eel River samples deviates from H-W equilibrium or displays linkage disequilibrium (LD) (Table 10). In contrast, four of the five samples from the Russian River deviate from H-W equilibrium. Adult Russian River samples from the Warm Spring Hatchery deviate from H-W equilibrium at the $\alpha = 0.0001$ level and display high levels of LD, with 19 and 10 of 21 pairwise combinations of loci displaying significant nonrandom associations for samples A and B, respectively. Because these samples do not conform to the assumption

Table 10. Within-sample genetic diversity for 14 coastal Chinook salmon populations genotyped at seven loci (*Ots-2*, *Ots-3*, *Ots-9*, *Ots-10*, Banks et al. 1999; *Oneµ-13*, Scribner et al. 1996; *Ots-104* and *Ots-107*, Nelson and Beacham 1999).

Sample	Year	Collection Site	Life Stage	N	H_e	H_o	N_a	F_{IS}	$P_{H\text{-}W}$
E1	1998	Ryan	Adult	9	0.54	0.49	4.3	0.27	0.74
E2	1998	Baechtal	Adult	17	0.71	0.70	6.4	0.06	0.21
E3	1998	Willits	Adult	9	0.66	0.81	5.1	-0.15	0.96
E4	1998	Long Valley	Adult	9	0.65	0.69	4.6	0.04	0.88
E5	1998	String	Adult	7	0.56	0.65	3.6	-0.07	0.81
E6	1999	Baechtal	Adult	18	0.73	0.76	6.9	0.00	0.88
E7	1999	Tomki	Adult	5	0.50	0.61	2.9	0.07	0.53
E8	1999	Outlet	Adult	6	0.60	0.65	3.7	0.05	0.44
E9	1999	Broaddus	Adult	6	0.55	0.61	4.0	0.00	0.88
RR1	1997	Warm Springs [a]	Adult	100	0.70	0.62	6.0	0.12*	***
RR2	1997	Warm Springs [b]	Adult	94	0.74	0.61	8.6	0.18*	***
RR3	1999	Forsyth	Adult	8	0.66	0.76	4.2	-0.04	0.93
RR4	1999	Mirabel	Smolt	72	0.77	0.69	12.9	0.10*	*
RR5	2000	Mirabel	Smolt	82	0.75	0.69	10.7	0.09*	***
Lag1	2000	Lagunitas	Adult	7	0.48	0.51	3.2	0.08	0.81
Total				449					

Note: H_e, expected heterozygosity; H_o, observed heterozygosity; N_a, average number of alleles per locus; $P_{H\text{-}W\text{-}C}$, Hardy-Weinberg probability test – Fisher's exact method; significance, $P \leq 0.05$*; $P<0.001$***

required to perform tests of heterogeneity, both samples are omitted from further analyses. Russian River smolt samples, Mirabel 1999, and Mirabel 2000, deviate from H-W equilibrium at the $\alpha = 0.05$ and $\alpha = 0.0001$ levels, respectively. Neither of the smolt samples displays linkage disequilibrium, however. The deviation from H-W equilibrium for Mirabel 2000 is caused by loci *Ots-10* and *One-13*.

The first test of genetic heterogeneity is performed at the watershed level for the Russian River samples and for the Eel River samples. The Russian River samples include Mirabel 99 and '00 and Forsyth 1999 (Table 2). The range in pairwise comparisons of F_{ST} statistics for the three samples is –0.0064 to 0.0097. Forsyth is not significantly different from either Mirabel sample, but Mirabel 99 differs from Mirabel 2000 at the $\alpha = 0.05$ level. For the Russian River, Forsyth 1999 and Mirabel 2000 are combined to form a homogeneous group. For the nine Eel River samples, F_{ST} is 0.013, not statistically different from zero, so the nine samples are combined to form a homogeneous group.

The second test of genetic heterogeneity is performed among populations. The UPGMA phylogram derived from CSE, based on seven loci, shows that the coastal Chinook populations from the Eel River, Russian River and Klamath, cluster on one side of the tree while the inland

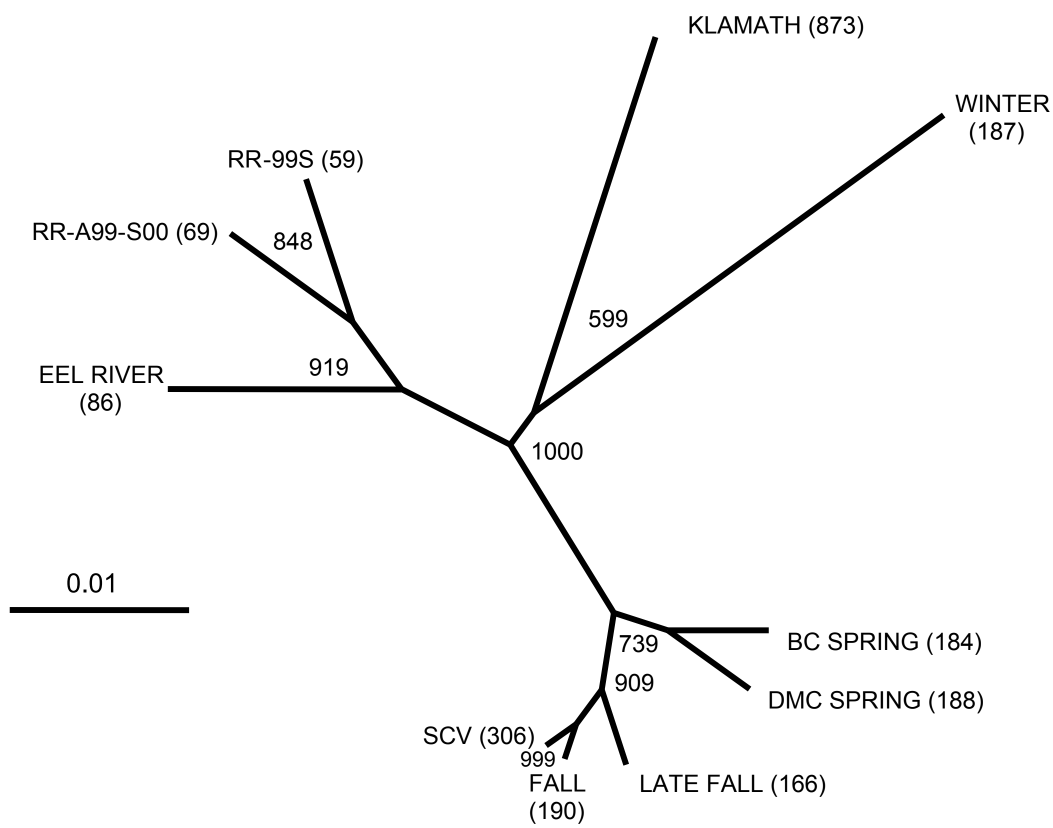

Fig. 9. A tree showing genetic relatedness based on CSE UPGMA from 7 microsatellite loci, with all Eel River samples combined. Russian River hatchery samples are excluded from analysis due to high linkage disequilibrium. Central Valley Chinook populations are from Banks et al. (2000; Table 1, fig. 4.) Numbers in parenthesis indicate sample sizes and numbers at the nodes indicate the number out of 1000 bootstrap simulations supporting a particular cluster. The scale indicates genetic distance.

Chinook populations from the Central Valley, Spring BS, Spring DC, Late Fall, Fall and the Santa Clara Valley, cluster on the other side of the tree (Fig. 9). This bifurcation is found in all 1000 trees made by bootstrapping loci. The Eel River and the Russian River cluster together, but the two populations are distinct from one another with a bootstrap value of 919. Although the

Russian River displays temporal structure, with a bootstrap value of 848, these samples are closer to each other than to samples from either the Eel or Klamath Rivers.

Discussion

Our final analysis of Chinook reveals quite a different picture than the preliminary results presented in previous reports. This change results primarily from the addition of new samples and careful scrutiny of the scoring of genotypes. No correction for family structure was needed, as the juvenile samples did not have high LD.

The major finding is that Chinook salmon in the Russian River are not closely related to Chinook salmon from either the Central Valley or the Eel River. A close relationship to Central Valley stocks might be postulated based on supposed straying of Central Valley hatchery stocks into the Russian River. Indeed, we see evidence of this in the very close affinity of Chinook in the Santa Clara Valley and Central Valley fall stocks (Fig. 9). On the other hand, owing to the diversion of Eel River water through Potter Valley into the Russian River, one might postulate a potential for enhanced gene flow between Russian River Chinook and Eel River Chinook mistakenly homing to this diverted Eel River water. This appears not to be the case. Chinook in the Russian River do appear to belong to a diverse set of coastal Chinook populations.

THE DEVELOPMENT AND MAINTENANCE OF ALTERNATIVE MALE-TYPES IN A POPULATION OF COHO SALMON.

Three adult phenotypes, 3-year-old "hooknosed" males, 3-year-old females and 2-year-old "jack" males represent coho salmon in California. During spawning, females defend an oviposition territory from other females. While brightly colored hooknosed males fight for access to females, jack males are much smaller and sneak into a female's oviposition site in order to attain egg fertilizations. Interestingly, large juvenile males are more likely to mature as jacks than are small juveniles (Gross, 1991). Additionally, there are at least three behavioral and morphological phenotypes reported in juveniles. These three phenotypes can be referred to as territorials, floaters and poolers (Puckett and Dill, 1985; Nielsen, 1992). Territorials are the largest; they hold and defend positions in the natal stream while floaters, the smallest, hold no permanent position and dash among the territorials. Poolers are intermediate in size and do not appear to defend territories. Territorials and floaters are found in areas of the creek that are marked by variation in water flow velocity, while poolers are found in areas that have little variation in water flow velocity, namely pools. No research has directly tied the observation of multiple juvenile behavioral phenotypes to the occurrence of alternative reproductive phenotypes in coho salmon. Dissertation research by graduate student Jason Watters examined the development, maintenance, and conservation significance of alternative male phenotypes in coho salmon (*Oncorhynchus kisutch*). The dissertation is being published in three separate articles, the abstracts of which follow.

Watters, J. V., S. C. Lema and G. A. Nevitt. 2002. Phenotype Management: A New Approach to Habitat Restoration. Biological Conservation, in press.
Abstract. The goal of habitat restoration is to provide environmental conditions that promote the maintenance and growth of target populations. But rarely is it considered how the allocation of resources influences the diversity of phenotypes in these populations. Here we present a framework for considering how habitat restoration can shape the development and expression of

phenotypes. We call this approach *phenotype management* as it entails restoring the resources in a habitat to manage phenotypic diversity. Phenotype management is achieved by manipulating the spatial and temporal distribution of resources to alter the degree of competition among individuals. Differences in competition, in turn, lead to changes in phenotypic and life history expression that affect population parameters including demography and effective population size (N_e). To illustrate how phenotype management can be applied, we explore how resource distributions shape variation in phenotypes in two imperiled fishes, Pacific salmon and desert pupfish. In both examples, modulating male reproductive phenotypes changes the allocation of reproductive success among population members to subsequently affect N_e. These examples further demonstrate that whether to increase or decrease phenotypic diversity depends on the primary conservation pressures faced by the species.

Waters, J. V., and G. A. Nevitt. Resource Clumping and Population Density Drive the Development of Alternative Phenotypes. Behavioral Ecology, in review.
Abstract. Though often eclipsed by genetic considerations, the environment plays a key role in directing development, and typically drives most individual variation within populations. Here, we describe how two simple parameters – resource clumping and population density – are likely to shape the distribution of growth rates in a population and affect the expression of alternative reproductive phenotypes. At low population densities, clumped resources increase the variance in growth while evenly spread resources decrease this variance. Increased population densities lead to a decrease in the mean growth rate, and eventually, in the case of clumped resources to a decreasing variance in growth. Thus, when phenotypic expression is contingent on growth rate, habitats with clumped resources are more likely to produce alternative phenotypes than habitats with evenly spread resources are and this is most probable at lower densities. We test these ideas empirically using a threatened species, coho salmon (*Oncorhynchus kisutch)* as a model system. Our results demonstrate that varying physical attributes of the rearing habitat dramatically influences the growth rates of juveniles and the subsequent expression of alternative male phenotypes at maturity.

Watters, J. V., and G. A. Nevitt. MS, in prep.
Abstract. Most studies of sexual selection investigate either intersexual or intrasexual interactions. Here I suggest that considering the simultaneous effects of inter- and intrasexual interactions will provide new insight into the evolution of mating systems and elaborate sexually selected traits. I present a model of mate choice in which females base their mating preferences on the heritable viability of males. In the model, male phenotypes are indicative of their viability. I show with the model that in order for males of lower fitness to attain reproductive success, they must contend free female mate choice by coercing females. Females and preferred high fitness males then must cooperate to facilitate mating and avoid the costs of coercion. When the costs of coercion are high relative to the benefits of cooperation, females may choose to mate with low fitness non-preferred males. In cases where coercion is common, cooperation to secure preferred matings may occur quickly. Indeed, I suggest that elaborate male traits are often those that are useful in coercion and that quick, efficient "sneak" mating may be a means to facilitate preferred matings. Where coercion cannot be avoided, I suggest that females may evolve life history characteristics that minimize the fitness costs of mating with non-preferred males.

This theory is the basis of the field observations that Watters has done on wild fish. Jason believes that hooknosed males are coercers and that jacks are cooperators. Jacks are much more likely to survive to maturity than hooknoses, so it is feasible that a female who mates with jacks can maximize her fitness, if the trait is not solely environmentally determined. These data being used to test this hypothesis are being analyzed.

DEVELOPMENT OF GEOGRAPHIC INFORMATION SYSTEMS

Overview

Researchers from REGIS (the Research Program in Environmental Planning and Geographic Information Systems, College of Environmental Design, UC Berkeley) in collaboration with researchers from Bodega Marine Laboratory (UC Davis) have developed a model for a web-based marine GIS (Geographic Information System) that focuses on coastal near-shore processes. The data layer inputs are marine physical attributes that have an impact on the health and survival of near-shore fisheries, such as coho salmon. The marine GIS is unique in that it incorporates data layers derived from near real-time data publicly available on the Internet. It is also the first GIS model to incorporate real-time ocean surface currents measurements derived from CODAR (Coastal Ocean Dynamics Application Radar) high frequency radar stations.

The URL for the working model of the GIS is **http://sonoma.regis.berkeley.edu/website/bml/salmon** (until 1/31/2003). We expect to move this site to **http://www.bml.ucdavis.edu** at some time in the near future.

Purpose

The intent of this project was not to compete with or duplicate the efforts of other projects but to explore ways to incorporate useful data pertaining to marine systems and fisheries in a relevant but novel GIS format. A number of excellent terrestrial databases have already been developed for salmon management such as the KRIS (Klamath River Information System) and RRIS (Russian River Information System) databases. Data pertaining to the marine environment are absent from these databases however. Marine physical factors have a significant impact on the health and productivity of fisheries. Salmon, for example, spend much of their lives in the ocean but resource managers have very little information about where these fish go between spawning events and what the conditions are that influence their growth and behavior. It is hoped that these terrestrial databases can eventually be combined with marine GIS databases in the future to provide a more complete picture of factors influencing commercial fisheries and the coastal environment.

Why a GIS mapserver?

Mapservers are a recent phenomenon and have evolved from the development of the Internet. In simple terms, they provide interactive map analyses and mapmaking capabilities to anyone with a computer connected to the web and running an up-to-date web browser. We chose to work with a web-based GIS rather than build a static GIS database because of its potential to deliver up-to-date information to broad audience in a timely manner. A minimal amount of GIS expertise is required to take advantage of this tool. The obvious benefit to resource managers, policy makers and educators is immediate access to current geographical data relevant to a particular problem, in this case fisheries management. Additions or updates to web-based databases can be made quickly on a single computer, the mapserver, avoiding the need to mail digital media to users whenever database changes occur. A web-based GIS can also provide data from real-time sources as we have demonstrated with this project.

Software and Computing Platform Specifications

The Microsoft (tm) Windows 2000 Server platform was chosen because it was the easiest and most cost-effective platform on which to run mapserver software. A key goal was to keep all data and software geared to a commonly used computing platform so that our custom programming efforts could be shared with other website developers. Our GIS uses ESRI's (Earth Systems Research Institute) ArcIMS 3.1 software, an industry standard.

Details of the custom PERL programming scripts used to develop the unique features of this GIS are included as an appendix to this report. A Cdrom, containing the database files, ArcIMS directory structure, and scripting code is also included with this report.

Description

This project was not intended to be a comprehensive database or analytical tool but a model framework to help guide the development of marine GIS databases in the future. The sample data layers that we have used are completely functional and include examples of important physical attributes of the local coastal environment. Sea surface temperature, ocean surface currents, wave heights, stream flows, stream sediment loads and stream temperatures are all accessible through the data layers or live-linked URLs. The UC Berkeley REGIS group was conscripted for this project because of their demonstrated expertise with environmental GIS development and their experience with incorporating publicly accessible Internet databases into GIS format. They identified and incorporated four web accessible data sources into our GIS model for this project. These include ocean current measurements from BML CODAR installations, NOAA Data Buoy Center (NDBC) data for buoys along the central California coast, the USGS Stream Gauge database for the Sonoma and Marin County area and the California Data Exchange Center (CDEC) stream monitoring stations for the Sonoma and Marin County area.

Salmon Genetics Data

In our original request for supplementary funds to explore the use of GIS as a management tool we proposed to incorporate genetic (allelle-frequency) data as a test dataset. The spatial distribution of genetically differentiated groups of coho salmon was of interest to resource managers and a GIS was an obvious and appropriate tool to display these types of data. Unfortunately, these data came from numerous agencies and the formats and metadata collected were not consistent from agency to agency. Specifically the spatially explicit information needed (i.e. geographic coordinates) to code the genetic data for display was different for each sample set. Some samples were labeled with a generic stream name or watershed name, while others referenced local features such as road mileposts, access road gates. However, we were able to develop a sample data layer from one of the datasets with the requisite spatial information to illustrate how tabular data might be incorporated into a GIS. The Olema Creek data samples (provided by the National Park Service) were recorded using specific pre-determined river reaches defined by specific geographic coordinates. Using the ArcIMS browser, any location along the creek can be selected with a click of the mouse. This activates a pop-up data table for that particular stream segment and lists the individual samples along with the corresponding metadata.

The allele-frequency data for the entire 1330-sample dataset (Appendix 1) were coded in a tabular format compatible with a GIS and it may be possible to retroactively add coordinate information to the data. However, the contributing agencies would need to invest a significant amount to standardize their data collection forms and agree on a protocol. Historic sample metadata would need to be appended with requisite spatial information and some of the samples may require input from the individuals who originally collected the samples. A few recommendations are made below that may help to make future data contributions more useful for display in map form and GIS analyses.

Recommendations

The primary limitation we encountered when attempting to visualize salmon genetics information in a GIS was the inconsistency or lack of spatial metadata provided with salmon fin clip samples. We recommend that future samples be provided with geographic coordinates obtained either from a handheld GPS (Global Positioning System) or USGS topographical map. Latitude and longitude (in decimal degrees) is the most flexible system for use with GIS software but UTM (North American Datum 1983) is also commonly used.

We also recommend that a standardized method of defining the stream reaches used by salmon be developed by the cooperating agencies. Aggregation of genetic samples to the reach level of resolution appears to be the optimal method based on the results of the salmon genetics study and demonstrated with the Olema Creek example. Point data (with geographic coordinates) provided with individual samples can always be aggregated into stream reaches at a later date, but in the long run it will be more cost effective to record the reach information at the time the sample is collected. A standardized data form agreed upon by all agencies would also be useful. This would minimize data input errors, when data are coded in digital format, and reduce costs.

We have demonstrated that a web-based GIS can be a useful method for timely dissemination of physical and ecological data pertaining to natural resource management of coastal marine systems. We have several suggestions that we can offer to assist with future development of interactive GIS as a marine resource management tool. First, the area covered by a fishery (such as salmon) is probably too large for a single GIS mapserver to handle in any great detail. We suggest that a coordinated effort be made to develop a standardized set of marine data layers to be archived and distributed at several regional or local level mapserver sites. A central computer hosting a more generalized data set could be established to field initial queries and then the query to the regional servers based on the level of detail required. We suggest that future GIS developers examine the marine data model currently being developed by ESRI and researchers at Oregon State University (http://www.esri.com/) as a starting point for marine data layer development. We have also identified several other for-fee data sources that would be very useful and are available as real-time data. These include polar orbiting AVHRR satellite imagery, which provides estimates of sea-surface temperature (SST) at 1km resolution, and SeaWIFs ocean color sensor data, which provide estimates of plankton content in coastal waters. Scripting to re-project these data for incorporation into a mapserver GIS are already available.

Other relevant data layers under development by the California Department of Fish and Game and available in the future include marine sanctuary and marine protected area boundaries and coastal kelp beds.

Additional CODAR sites should be added to real-time databases in the future in order to expand the coverage area for ocean surface current measurements. Currently there are twelve high frequency radar stations along the California coast covering roughly five percent of the California coastline. The southern most station is located on the Mexico border at Borderfield State Park and the northern-most is located at point St. George near Crescent City, California and operated by Oregon State University (OSU also operates five radars along the Oregon coast). The manufacturers (CODAR Ocean Sensors of Los Altos, California) have stated that there are a number of proposals in review that may help fund a coastal CODAR array covering the entire California coast. If these proposals are successful, arrangements should be made with the CODAR owner/operators for access to the real-time data for eventual inclusion into a mapserver.

Several large projects underway will develop observation systems that will eventually cover the entire coast of California. All of these data stations are designed to provide data in real-time and will be remotely accessible via the Internet. We expect that these could be easily adapted for use in a comprehensive marine GIS using the scripting methods developed by REGIS. A list of California coastal monitoring projects and contact information can be found at the NOAA website http://www.noaa.gov).

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APPENDIX 1. TABLE OF ALLELIC FREQUENCIES FOR 33 SAMPLES OF COHO SALMON IN CALIFORNIA

Allelic frequencies, expected and observed heterozygosities (*H exp.*, *H obs.*), Wright's inbreeding coefficient (F_{IS}), and its significance (*, P<0.05; **, P<0.01; ***, P<0.001), for seven microsatellite DNA markers in 33 samples of coho salmon populations in California.

	Southern Oregon / Northern California											South of San Francisco					
Ots-103	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	30	15	36	17	77	81	16	77	19	30	45	31	17	39	63	23	20
192	-	-	-	-	-	-		-	-	-	-	-	-	-	-	-	-
196	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
200	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
204	0.033	-	0.028	-	0.013	-	-	-	-	-	-	-	-	-	-	-	-
208	-	-	-	-	-	-	-	-	-	-	0.022	-	-	-	-	-	-
212	-	-	-	0.147	0.007	0.043	0.094	0.039	0.053	-	-	-	-	-	-	-	-
216	0.033	-	-	-	-	0.006	-	0.033	0.211	-	-	-	-	-	-	-	-
220	0.100	0.067	-	-	-	0.148	0.375	0.162	0.053	0.117	0.033	-	-	-	-	-	-
224	0.050	0.033	0.014	-	0.033	0.074	0.063	0.026	-	0.367	0.044	0.016	-	0.013	0.024	-	-
228	0.017	0.067	-	-	-	0.142	-	0.046	-	0.050	-	0.048	-	0.051	0.008	0.130	0.125
232	0.033	0.233	0.083	-	0.065	0.093	-	0.007	0.026	0.033	-	0.032	-	0.051	0.056	0.022	-
234	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
236	0.017	0.033	-	0.029	0.020	0.086	0.250	0.065	0.211	0.183	0.389	0.177	-	0.321	0.373	0.152	0.350
240	-	-	-	-	0.071	0.049	-	-	-	-	0.022	0.371	0.588	0.218	0.230	0.348	0.375
244	0.017	-	-	0.029	0.046	0.043	-	0.007	-	-	-	0.032	0.059	0.077	0.048	0.044	0.025
248	0.050	0.033	0.042	0.118	0.104	-	-	0.097	-	-	-	0.016	-	-	0.008	0.044	-
252	0.033	0.100	0.097	0.088	0.110	-	-	0.013	0.026	0.050	-	-	-	-	-	-	-
254	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
256	-	-	-	-	0.007	0.006	0.063	0.058	0.105	-	0.033	-	-	0.013	0.032	0.022	-
260	-	-	-	-	-	-	0.031	0.013	-	-	-	-	-	-	0.008	-	-
264	0.167	0.033	0.208	0.059	0.149	0.031	0.031	0.020	0.053	-	-	0.032	-	-	-	-	-
268	0.067	0.100	0.014	0.029	-	-	-	0.046	0.053	0.017	-	-	-	-	0.024	-	-
272	0.183	0.167	0.486	0.382	0.370	0.210	-	-	0.026	0.100	-	-	-	-	-	-	-
274	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
276	0.033	-	0.014	-	-	-	-	0.091	0.026	-	0.022	-	-	-	-	-	-
280	0.117	0.133	0.014	0.118	0.007	-	-	-	0.053	-	-	-	-	-	0.008	-	-
284	0.050	-	-	-	-	-	-	-	-	-	-	0.226	0.353	0.192	0.143	0.239	0.125
288	-	-	-	-	-	0.025	-	0.058	-	-	-	-	-	-	-	-	-
292	-	-	-	-	-	0.019	-	0.013	-	-	-	-	-	-	-	-	-
296	-	-	-	-	-	0.006	-	-	-	-	0.200	-	-	-	-	-	-
300	-	-	-	-	-	0.019	0.094	0.208	0.105	0.083	0.233	0.048	-	0.064	0.040	-	-
H exp.	0.897	0.867	0.701	0.791	0.805	0.884	0.770	0.893	0.873	0.795	0.749	0.772	0.526	0.797	0.778	0.777	0.705
H obs.	0.867	0.800	0.639	0.765	0.584	0.938	0.563	0.857	0.368	0.967	0.733	0.742	0.529	0.846	0.778	0.913	0.850
F_{IS}	0.050	0.111	0.102	0.063	0.280	-0.055	0.299	0.047	0.596	-0.200	0.032	0.055	0.024	-0.048	0.008	-0.154	-0.181
Sig.					***		*		***						*		

	Southern Oregon / Northern California											South of San Francisco					
Ots-2	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	30	15	36	17	77	81	16	76	20	30	46	31	17	39	65	23	20
176	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
178	0.050	0.133	0.014	-	0.026	0.136	-	0.053	0.050	-	0.076	-	-	-	-	-	
180	0.533	0.433	0.528	0.412	0.312	0.630	0.375	0.355	0.300	0.200	0.489	0.661	0.765	0.808	0.854	0.826	0.950
182	0.250	0.200	0.125	0.147	0.091	-	-	0.026	0.025	-	-	-	0.059	0.013	0.023	-	-
184	0.117	0.233	0.333	0.324	0.435	0.099	-	0.020	0.075	0.067	-	-	-	-	0.008	0.022	-
186	-	-	-	-	0.007	-	-	-	-	-	-	-	-	-	-	-	-
187	-	-	-	0.118	0.117	0.049	0.625	0.447	0 . 4 5 0	0.517	0.435	-	-	0.013	0.015	-	-
188	0.050	-	-	-	0.013	0.086	-	0.099	0.100	0.217	-	0.339	0.177	0.167	0.100	0.152	0.050
190	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
192	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.634	0.700	0.595	0.690	0.691	0.566	0.469	0.660	0.689	0.642	0.566	0.448	0.381	0.320	0.260	0.294	0.095
H obs.	0.633	0.867	0.472	0.765	0.636	0.556	0.250	0.697	0.850	0.700	0.652	0.548	0.412	0.385	0.262	0.348	0.100
F_{IS}	0.019	-0.205	0.219	-0.078	0.085	0.024	0.492	-0.050	-0.210	-0.074	-0.142	-0.209	-0.052	-0.191	0.002	-0.162	-0.027
Sig.			*			*				*							

iso-Ots2	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99l	SCY99up
(N)	30	15	36	16	75	79	15	75	19	30	44	31	17	39	65	23	19
199	0.050	0.033	0.167	-	0.073	-	-	-	-	-	-	-	-	-	-	-	-
201	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
203	-	-	-	0.031	0.013	0.006	-	-	-	-	-	-	-	-	-	-	-
205	0.350	0.200	0.208	0.375	0.280	0.260	0.400	0.573	0.658	0.417	0.239	0.613	0.529	0.718	0.462	0.609	0.737
207	0.017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
209	0.017	-	0.014	-	-	-	-	-	-	-	-	-	-	-	-	-	-
211	-	-	-	-	-	0.038	0.033	0.007	-	-	-	-	-	-	-	0.044	-
213	0.050	0.067	0.153	0.063	0.147	0.006	-	0.100	-	0.133	0.023	0.016	-	0.039	0.085	0.022	-
215	-	0.067	0.042	0.063	-	0.032	0.167	0.173	0.158	0.100	0.284	0.065	-	0.064	0.062	-	-
217	0.117	0.100	0.069	0.031	0.080	0.070	0.033	-	0.026	-	0.114	0.016	-	-	0.015	-	-
219	0.017	-	0.028	0.125	0.053	-	-	-	0.105	-	0.011	0.016	-	-	-	-	-
221	0.067	0.067	0.069	0.094	0.027	0.146	0.067	0.120	-	0.133	0.227	0.032	-	0.039	0.015	-	0.053
223	0.033	0.233	0.014	-	0.040	0.177	-	0.013	0.026	0.083	-	0.016	-	0.039	0.069	-	-
225	0.033	0.067	0.083	0.063	0.107	-	-	-	-	-	0.046	-	-	-	-	-	-
227	0.017	0.067	-	0.031	0.053	0.101	0.300	0.013	0.026	0.133	0.057	0.226	0.471	0.103	0.292	0.326	0.211
229	-	-	0.014	0.094	0.093	0.101	-	-	-	-	-	-	-	-	-	-	-
231	0.067	0.100	0.028	0.031	0.007	0.025	-	-	-	-	-	-	-	-	-	-	-
233	0.017	-	-	-	-	0.006	-	-	-	-	-	-	-	-	-	-	-
241	-	-	-	-	-	0.006	-	-	-	-	-	-	-	-	-	-	-
245	-	-	-	-	-	0.006	-	-	-	-	-	-	-	-	-	-	-
247	-	-	0.014	-	-	0.006	-	-	-	-	-	-	-	-	-	-	-
249	0.050	-	0.042	-	0.013	0.013	-	-	-	-	-	-	-	-	-	-	-
251	0.050	-	-	-	0.007	-	-	-	-	-	-	-	-	-	-	-	-
253	-	-	0.014	-	0.007	-	-	-	-	-	-	-	-	-	-	-	-
257	-	-	0.014	-	-	-	-	-	-	-	-	-	-	-	-	-	-
260	0.050	-	0.028	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.839	0.862	0.882	0.811	0.860	0.851	0.716	0.616	0.529	0.756	0.792	0.567	0.498	0.466	0.685	0.521	0.410
H obs.	0.833	0.867	0.889	0.750	0.933	0.798	0.800	0.547	0.632	0.800	0.773	0.484	0.353	0.436	0.523	0.478	0.421
F_{IS}	0.024	0.029	0.006	0.107	-0.079	0.069	-0.084	0.120	-0.168	-0.041	0.036	0.163	0.319	0.076	0.244	0.104	0.000
Sig.		*	**		***	*		*				*			***		

Ots-3	Southern Oregon / Northern California											South of San Francisco					
	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	29	13	33	17	66	78	16	74	22	30	41	31	17	39	65	23	19
120	0.017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
123	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
130	0.035	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
133	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
135	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
137	-	-	-	-	-	0.039	0.031	0.061	0.068	0.083	0.134	-	-	-	-	-	-
139	-	-	-	-	-	-	-	-	0.023	0.017	-	-	-	-	-	-	-
141	0.052	0.077	-	0.059	0.061	0.199	0.094	0.088	0.091	0.050	0.281	0.242	0.235	0.333	0.331	0.326	0.526
143	0.017	-	-	-	-	-	0.031	-	-	0.017	-	-	-	-	-	-	-
145	0.052	-	0.136	-	0.091	0.115	-	0.007	0.023	0.033	0.146	0.339	0.324	0.321	0.208	0.196	0.132
147	0.103	0.269	0.061	0.059	0.038	0.135	0.281	0.108	0.114	0.250	0.195	0.258	0.441	0.192	0.323	0.326	0.184
149	0.035	-	0.061	0.059	0.030	0.006	0.031	0.081	0.068	-	-	-	-	-	-	-	-
151	0.035	0.039	0.015	-	0.061	0.026	-	-	-	-	0.012	-	-	-	-	-	-
153	0.535	0.346	0.500	0.647	0.644	0.404	0.406	0.487	0.341	0.467	0.159	0.129	-	0.115	0.139	0.087	0.132
155	0.069	0.192	0.076	0.029	0.023	0.019	-	0.014	-	-	-	0.016	-	0.039	-	0.065	0.026
157	0.052	0.077	0.152	0.147	0.053	0.058	0.094	0.155	0.273	0.083	-	0.016	-	-	-	-	-
159	-	-	-	-	-	-	0.031	-	-	-	0.024	-	-	-	-	-	-
161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
163	-	-	-	-	-	-	-	-	-	-	0.049	-	-	-	-	-	-
H exp.	0.687	0.757	0.695	0.548	0.564	0.760	0.734	0.709	0.778	0.702	0.816	0.743	0.645	0.734	0.724	0.737	0.654
H obs.	0.690	0.692	0.727	0.588	0.546	0.821	0.813	0.689	0.727	0.733	0.805	0.774	0.882	0.795	0.508	0.913	0.579
F_{IS}	0.013	0.126	-0.031	-0.042	0.041	-0.073	-0.074	0.035	0.088	-0.028	0.025	-0.026	-0.341	-0.069	0.306	-0.217	0.141
Sig.															***		

One-13	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	21	10	27	16	69	81	16	75	20	29	34	31	13	39	64	23	19
193	-	-	-	-	-	0.006	-	0.007	-	-	-	-	-	-	0.008	-	-
195	0.024	0.050	0.019	-	0.007	-	-	-	-	-	-	-	-	-	-	-	-
197	0.024	-	0.056	-	0.145	-	-	-	-	-	-	0.194	0.115	0.167	0.086	0.196	0.053
201	0.095	0.100	0.056	0.031	0.087	0.111	0.094	0.160	0.275	0.172	0.044	0.419	0.231	0.333	0.461	0.304	0.447
203	0.071	0.300	0.019	0.125	0.058	0.105	-	0.067	0.075	0.086	-	0.016	-	-	0.008	-	-
205	0.048	-	0.019	0.063	0.022	-	0.063	0.027	-	0.017	-	0.016	-	0.039	0.039	0.087	0.105
207	-	-	-	0.094	0.036	0.025	-	0.007	0.025	-	-	0.081	0.039	0.077	0.055	0.261	0.026
209	-	-	-	-	0.007	0.185	0.188	0.067	0.075	0.103	0.221	-	0.077	-	-	-	-
211	0.048	0.100	0.019	0.156	0.073	0.099	-	0.047	0.075	0.069	0.029	0.016	0.231	0.051	0.016	0.065	0.132
213	0.119	-	0.056	-	0.007	0.019	-	0.013	-	-	-	0.065	0.077	0.128	0.148	0.022	0.158
215	0.262	0.300	0.370	0.250	0.275	0.284	0.438	0.293	0.175	0.362	0.338	0.161	0.192	0.141	0.117	0.022	-
217	-	0.100	0.037	0.094	0.065	0.093	0.031	0.100	0.075	0.069	0.103	-	0.039	0.013	0.008	-	-
219	0.286	0.050	0.167	0.063	0.051	0.068	0.063	0.133	0.150	0.086	0.206	0.032	-	-	0.016	-	-
221	-	-	0.130	0.094	0.123	-	0.125	0.080	0.075	-	0.059	-	-	-	-	0.022	-
223	0.024	-	0.056	0.031	0.044	-	-	-	-	0.017	-	-	-	0.013	-	0.022	0.053
225	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.008	-	0.026
227	-	-	-	-	-	0.006	-	-	-	0.017	-	-	-	0.039	0.031	-	-
229	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
277	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.815	0.785	0.803	0.861	0.861	0.838	0.740	0.842	0.843	0.803	0.778	0.748	0.828	0.813	0.738	0.787	0.740
H obs.	0.762	0.800	0.593	0.938	0.884	0.877	0.875	0.867	0.950	0.931	0.794	0.839	0.923	0.897	0.672	0.913	0.737
F_{IS}	0.090	0.034	0.280	-0.056	-0.019	-0.040	-0.151	-0.022	-0.102	-0.142	-0.006	-0.105	-0.075	-0.091	0.098	-0.138	0.031
Sig.			*														

P-53	Southern Oregon / Northern California											South of San Francisco					
	KIGHA97an	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	29	15	36	16	77	81	14	77	20	29	47	31	17	37	65	23	20
150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
161	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
163	0.207	0.133	0.181	0.063	0.331	0.043	-	-	-	-	0.170	-	-	-	-	-	-
165	-	0.033	-	-	0.007	0.006	-	-	-	-	-	-	-	-	-	-	-
167	0.017	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
169	0.086	0.067	0.250	0.031	0.020	0.173	0.107	0.357	0.350	0.310	0.170	0.436	0.618	0.351	0.362	0.348	0.150
171	0.017	0.067	-	-	-	0.105	0.036	0.084	0.050	-	0.213	0.242	-	0.243	0.246	0.304	0.450
173	0.052	-	0.014	-	-	0.031	-	-	-	-	0.043	-	-	-	-	-	-
175	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
177	0.017	0.200	-	-	-	0.191	0.393	0.266	0.325	0.207	0.170	0.016	-	0.027	0.008	-	-
179	0.035	0.100	-	0.094	0.046	0.111	0.143	0.136	0.200	0.155	0.160	0.113	0.088	0.243	0.277	0.152	0.150
181	0.466	0.233	0.528	0.500	0.487	0.235	0.286	0.149	0.075	0.328	0.075	0.032	-	0.041	0.031	-	-
183	0.069	0.033	0.028	-	0.039	0.080	-	-	-	-	-	0.016	-	0.014	0.015	-	0.050
185	0.035	0.133	-	0.313	0.065	0.025	0.036	0.007	-	-	-	0.145	0.294	0.081	0.062	0.196	0.200
191	-	-	-	-	0.007	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.722	0.849	0.625	0.639	0.645	0.845	0.730	0.754	0.724	0.730	0.835	0.716	0.524	0.749	0.727	0.725	0.710
H obs.	0.690	0.800	0.722	0.500	0.584	0.877	0.643	0.779	0.650	0.690	0.787	0.807	0.647	0.730	0.446	0.652	0.850
F_{IS}	0.063	0.092	-0.141	0.248	0.100	-0.031	0.155	-0.028	0.127	0.072	0.068	-0.109	-0.205	0.040	0.393	0.122	-0.172
Sig.													*		***		

Oki-1	KIGHA97a	KIGHA97j	KIGHA97ll	TRHA97s	TRHA97l	LRS00	EHOLA97	EREDS97	EREDA98	ESPRS99	MATS98	WADY99l	WADY99u	SCA95c	SCA9798c	SCY99low	SCY99up
(N)	30	15	36	17	77	81	15	76	19	29	48	30	17	37	62	22	19
88	0.183	0.133	0.014	0.029	0.039	0.019	0.033	0.013	-	0.103	-	-	-	-	-	-	-
92	0.033	0.033	0.056	-	-	0.006	-	-	-	-	-	-	-	-	-	-	-
96	0.333	0.500	0.417	0.206	0.299	0.198	0.033	0.145	0.026	0.241	0.208	-	-	-	-	0.023	-
100	0.083	0.067	0.222	0.265	0.240	0.167	0.033	0.059	0.053	0.069	0.115	-	-	-	-	-	-
104	0.100	-	0.028	0.029	0.052	0.093	-	0.013	0.079	0.035	0.135	0.050	-	0.014	0.008	0.046	0.132
108	-	-	0.028	0.088	0.007	0.006	0.200	0.026	-	0.052	-	-	-	-	-	-	-
112	-	-	-	-	0.007	0.031	0.333	0.493	0.579	0.466	0.344	0.400	0.765	0.581	0.476	0.636	0.500
116	0.150	0.033	0.083	0.235	0.201	0.080	0.333	0.132	0.132	0.017	0.021	-	-	-	0.032	0.023	-
120	-	-	-	-	0.007	0.025	-	0.053	0.079	0.017	0.115	-	-	-	-	-	-
124	0.050	0.133	0.083	0.118	0.149	0.191	-	0.020	0.026	-	-	0.250	-	0.068	0.234	0.136	0.184
128	0.033	-	0.014	-	-	0.124	-	0.040	-	-	-	0.217	0.029	0.189	0.129	0.023	0.079
130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
132	-	-	-	-	-	0.019	-	-	-	-	-	0.083	0.206	0.149	0.105	0.114	0.105
136	-	-	-	-	-	-	0.033	0.007	0.026	-	-	-	-	-	0.016	-	-
140	-	-	-	0.029	-	0.043	-	-	-	-	0.063	-	-	-	-	-	-
144	0.033	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148	-	0.067	0.056	-	-	-	-	-	-	-	-	-	-	-	-	-	-
152	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
160	-	0.033	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.810	0.702	0.755	0.808	0.786	0.862	0.733	0.709	0.630	0.705	0.790	0.721	0.372	0.600	0.690	0.560	0.681
H obs.	0.700	0.800	0.722	0.882	0.753	0.877	0.800	0.776	0.737	0.690	0.750	0.700	0.471	0.676	0.484	0.636	0.684
F_{IS}	0.152	-0.105	0.057	-0.062	0.048	-0.010	-0.057	-0.088	-0.143	0.039	0.061	0.046	-0.237	-0.113	0.306	-0.114	0.023
Sig.					*						*				**		

	Central California															
Ots-103	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	44	42	40	21	16	64	8	25	39	6	128	17	58	106	11	23
192	-	-	-	-	-	-	-	-	-	-	-	-	-	0.009	-	-
196	-	-	-	-	-	-	-	-	-	-	0.008	-	0.043	0.009	-	-
200	-	-	-	-	-	-	-	-	-	-	0.008	0.029	0.009	0.005	-	-
204	-	0.012	0.013	-	-	-	-	-	-	-	-	-	0.009	-	-	-
208	0.023	-	-	-	-	-	-	-	-	-	-	0.059	-	-	-	-
212	-	0.012	-	0.024	-	-	-	-	-	-	0.020	-	-	-	-	-
216	-	-	-	-	0.031	-	-	-	-	-	0.016	0.029	0.009	-	-	-
220	-	0.012	0.013	-	-	0.016	-	0.100	0.051	-	0.008	-	-	-	0.273	0.239
224	0.102	0.107	0.075	0.048	-	0.148	-	0.200	0.269	-	0.059	0.088	0.060	0.076	0.136	0.065
228	-	0.095	0.075	-	-	0.039	-	0.020	0.077	0.500	0.023	0.059	0.009	0.028	-	-
232	0.034	0.060	0.038	0.024	-	0.133	-	0.040	0.077	-	0.109	0.118	0.181	0.179	0.136	0.261
234	-	-	-	-	0.031	-	-	-	-	-	-	-	-	-	-	-
236	0.273	0.250	0.225	0.095	0.344	0.227	0.063	0.280	0.218	0.417	0.320	0.265	0.276	0.302	0.046	0.174
240	0.057	0.012	-	-	0.063	0.063	-	-	-	-	0.039	0.029	0.043	0.014	-	0.065
244	0.011	0.095	0.138	0.071	0.094	0.078	0.438	0.140	0.128	0.083	0.066	0.088	0.009	0.009	-	0.022
248	0.034	-	-	-	-	-	-	-	-	-	0.020	0.059	0.043	0.019	-	-
252	-	0.012	-	0.024	0.031	-	-	-	-	-	0.008	0.029	-	-	0.046	-
254	0.011	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
256	0.011	0.024	0.025	-	-	0.008	-	-	-	-	0.004	0.029	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	0.004	-	-	-	-	-
264	0.034	0.024	0.025	-	-	0.047	-	-	-	-	0.063	0.029	0.086	0.024	-	-
268	0.068	0.036	0.025	0.262	0.156	0.016	-	-	-	-	0.027	-	0.009	0.019	-	-
272	0.102	0.119	0.100	0.143	-	0.023	-	-	-	-	0.074	0.059	0.035	0.090	0.136	-
274	-	-	-	-	-	-	-	-	-	-	0.004	-	-	-	-	-
276	-	-	-	-	-	-	-	-	-	-	-	-	-	0.005	-	-
280	-	0.012	0.025	-	-	0.016	0.125	0.040	0.039	-	-	-	0.017	0.028	-	-
284	-	-	-	-	-	0.008	-	-	-	-	-	-	0.026	0.005	-	-
288	-	-	-	-	-	-	-	-	-	-	-	-	0.026	0.005	-	-
292	-	-	0.013	-	-	0.039	-	0.140	0.115	-	0.020	-	-	0.014	-	-
296	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
300	0.239	0.119	0.213	0.310	0.250	0.141	0.375	0.040	0.026	-	0.102	0.029	0.112	0.160	0.227	0.174
H exp.	0.836	0.873	0.860	0.797	0.779	0.873	0.648	0.827	0.834	0.569	0.853	0.881	0.859	0.834	0.814	0.805
H obs.	0.773	0.810	0.800	0.810	0.750	0.797	0.625	0.880	0.872	1.000	0.813	0.941	0.845	0.793	0.455	0.652
F_{IS}	0.087	0.084	0.082	0.009	0.070	0.095	0.103	-0.043	-0.033	-0.714	0.052	-0.039	0.025	0.054	0.479	0.211
Sig.	*		*												**	*

	Central California															
Ots-2	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	44	43	40	19	16	64	7	25	39	7	135	17	67	105	15	24
176	-	-	-	-	-	-	-	-	-	-	0.022	-	-	0.005	0.033	0.021
178	0.023	0.058	0.100	0.026	-	0.063	-	-	-	-	0.026	-	-	0.014	-	-
180	0.671	0.802	0.625	0.763	0.531	0.688	0.929	0.740	0.603	1.000	0.563	0.647	0.754	0.667	0.800	0.646
182	0.057	0.023	0.050	0.053	0.125	0.016	-	-	-	-	0.096	0.029	0.067	0.043	-	-
184	0.011	0.023	0.100	-	0.031	0.102	-	0.120	0.141	-	0.044	0.059	0.015	0.048	0.033	-
186	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
187	0.011	-	-	0.026	0.031	0.031	-	0.020	0.039	-	0.093	0.147	0.067	0.081	-	0.313
188	0.193	0.093	0.113	0.132	0.281	0.102	0.071	0.120	0.218	-	0.156	0.059	0.097	0.143	0.133	0.021
190	0.034	-	0.013	-	-	-	-	-	-	-	-	0.029	-	-	-	-
192	-	-	-	-	-	-	-	-	-	-	-	0.029	-	-	-	-
H exp.	0.508	0.343	0.574	0.396	0.621	0.502	0.133	0.423	0.568	-	0.638	0.550	0.413	0.524	0.340	0.484
H obs.	0.409	0.372	0.600	0.474	0.563	0.500	0.143	0.480	0.667	-	0.585	0.471	0.373	0.514	0.333	0.500
F_{IS}	0.206	-0.073	-0.033	-0.170	0.126	0.011	0.000	-0.114	-0.161	-	0.086	0.174	0.104	0.024	0.054	-0.011
Sig.	*											*				

iso-Ots2	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	43	43	39	18	16	65	7	25	39	8	128	17	9	103	13	23
199	-	-	-	-	-	0.008	-	-	-	-	-	-	-	-	-	-
201	0.012	-	-	-	-	-	-	-	-	-	0.004	0.029	-	-	-	-
203	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
205	0.477	0.267	0.154	0.333	0.469	0.285	0.500	0.620	0.500	-	0.473	0.353	0.611	0.515	0.423	0.544
207	-	-	0.013	-	-	0.008	-	-	-	-	0.016	-	-	-	-	-
209	-	-	-	0.028	0.031	-	-	-	-	-	-	-	-	-	-	-
211	0.128	0.116	0.205	0.028	0.156	0.123	-	0.060	0.051	-	0.051	0.177	-	0.024	0.077	0.044
213	-	-	0.013	-	-	0.039	0.214	0.020	0.128	0.250	0.016	-	-	0.049	-	-
215	0.116	0.198	0.218	0.250	0.063	0.154	0.286	-	-	-	0.203	0.147	0.222	0.223	0.039	-
217	-	0.047	0.192	-	-	0.069	-	-	-	-	0.066	0.059	-	0.015	0.039	-
219	-	-	-	0.028	-	-	-	-	-	-	-	-	-	-	-	-
221	0.035	0.058	0.026	0.056	0.063	0.046	-	-	0.039	-	0.020	0.029	0.056	0.053	-	-
223	-	-	-	-	-	0.008	-	0.020	0.064	0.313	0.016	-	-	0.005	-	-
225	-	0.035	0.051	-	-	0.008	-	-	-	-	0.023	-	-	-	0.077	-
227	0.233	0.198	0.103	0.278	0.219	0.169	-	0.100	0.218	0.313	0.106	0.206	0.111	0.117	0.346	0.413
229	-	0.012	-	-	-	0.008	-	-	-	-	-	-	-	-	-	-
231	-	0.047	0.013	-	-	0.054	-	-	-	0.125	0.004	-	-	-	-	-
233	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
241	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
245	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
247	-	-	-	-	-	0.023	-	0.180	-	-	0.004	-	-	-	-	-
249	-	0.023	0.013	-	-	-	-	-	-	-	-	-	-	-	-	-
251	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
253	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
257	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
260	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.687	0.827	0.835	0.744	0.699	0.839	0.622	0.569	0.678	0.727	0.716	0.775	0.562	0.666	0.686	0.532
H obs.	0.581	0.721	0.718	0.833	0.813	0.846	0.714	0.560	0.718	0.875	0.703	0.824	0.444	0.680	0.308	0.652
F_{IS}	0.166	0.140	0.153	-0.092	-0.130	0.000	-0.071	0.036	-0.046	-0.140	0.021	-0.032	0.264	-0.016	0.579	-0.204
Sig.															***	

Central California

Ots-3	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	43	40	31	21	16	64	6	25	39	7	98	16	64	106	1	24
120	-	-	-	-	-	-	-	-	-	-	0.010	-	-	-	-	-
123	-	-	-	-	-	0.016	-	-	-	-	-	-	-	-	-	-
125	-	-	-	-	-	-	-	-	-	-	-	-	-	0.005	-	-
130	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
133	0.012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
135	-	-	-	-	-	-	-	-	-	-	-	0.031	-	-	-	-
137	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
139	0.012	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
141	0.140	0.063	0.048	0.214	0.125	0.094	0.083	0.060	0.039	-	0.179	0.313	0.117	0.231	-	0.250
143	-	-	-	-	-	-	-	-	0.013	-	-	-	-	-	-	-
145	0.326	0.175	0.290	0.143	0.250	0.305	0.667	0.460	0.436	0.500	0.311	0.313	0.352	0.283	-	0.125
147	0.116	0.200	0.307	0.214	0.125	0.180	0.250	-	-	-	0.260	0.125	0.273	0.354	-	0.313
149	0.012	-	-	-	-	0.023	-	-	-	-	-	-	0.039	0.009	-	-
151	0.070	0.038	0.032	0.143	-	-	-	-	-	-	0.026	0.063	0.023	0.005	0.500	0.125
153	0.314	0.488	0.307	0.238	0.375	0.305	-	0.400	0.385	0.357	0.199	0.125	0.164	0.085	0.500	0.042
155	-	-	-	-	-	0.008	-	-	-	-	0.005	-	-	-	-	0.083
157	-	0.038	0.016	0.048	0.031	0.047	-	0.080	0.128	0.143	0.005	0.031	0.031	0.028	-	0.021
159	-	-	-	-	0.094	0.016	-	-	-	-	-	-	-	-	-	0.042
161	-	-	-	-	-	0.008	-	-	-	-	0.005	-	-	-	-	-
163	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.757	0.685	0.724	0.808	0.756	0.770	0.486	0.618	0.644	0.602	0.763	0.768	0.758	0.733	0.500	0.798
H obs.	0.837	0.600	0.710	0.857	0.875	0.813	0.500	0.600	0.718	1.000	0.816	0.875	0.609	0.726	1.000	0.875
F_{IS}	-0.094	0.137	0.036	-0.036	-0.126	-0.047	0.062	0.050	-0.102	-0.615	-0.065	-0.108	0.204	0.014	-	-0.076
Sig.		**											***	*		

One-13	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	40	41	31	21	15	64	4	25	39	8	114	15	57	105	2	21
193	0.013	0.024	0.016	-	-	0.039	-	-	-	-	0.013	-	0.009	0.019	-	0.048
195	-	-	-	0.048	-	0.016	-	-	-	-	0.013	-	-	0.005	-	-
197	0.050	0.122	0.081	0.071	0.133	0.047	-	0.160	0.282	0.188	0.057	0.067	-	0.024	-	-
201	0.275	0.378	0.307	0.143	0.267	0.289	0.500	0.260	0.218	0.188	0.276	0.400	0.123	0.271	-	0.714
203	-	-	0.016	-	-	0.008	-	-	0.013	-	0.031	-	0.044	0.014	0.500	0.048
205	0.075	-	0.032	-	0.033	0.023	0.125	-	-	-	0.044	-	0.079	0.014	0.250	-
207	0.038	-	0.032	0.071	0.100	0.023	-	-	-	-	0.022	0.033	-	0.019	-	0.024
209	0.163	0.012	-	0.071	-	-	-	0.060	0.090	0.188	0.040	-	-	0.010	0.250	-
211	-	0.012	-	0.095	0.033	0.047	-	-	0.013	-	0.022	0.067	0.035	0.119	-	-
213	0.125	0.012	0.081	0.143	0.167	0.086	-	0.060	0.039	-	0.088	0.100	0.132	0.081	-	-
215	0.125	0.134	0.113	0.095	0.167	0.102	0.125	0.100	0.039	-	0.118	0.067	0.175	0.110	-	-
217	0.063	0.110	0.194	0.095	-	0.117	0.125	0.040	0.051	-	0.105	0.033	0.149	0.076	-	0.024
219	0.050	0.134	0.016	0.119	0.067	0.086	0.125	0.240	0.205	0.438	0.044	-	0.035	0.129	-	0.024
221	-	-	0.016	-	-	0.008	-	-	-	-	0.048	0.033	0.097	0.019	-	0.048
223	-	0.024	0.016	-	-	0.047	-	-	-	-	0.018	-	0.009	-	-	-
225	-	-	-	-	-	-	-	-	-	-	0.004	-	0.018	-	-	-
227	0.025	0.037	0.081	0.048	0.033	0.063	-	0.080	0.051	-	0.057	0.200	0.061	0.076	-	0.071
229	-	-	-	-	-	-	-	-	-	-	-	-	0.035	0.010	-	-
277	-	-	-	-	-	-	-	-	-	-	-	-	-	0.005	-	-
H exp.	0.850	0.791	0.833	0.898	0.838	0.864	0.688	0.824	0.814	0.703	0.874	0.773	0.889	0.863	0.625	0.476
H obs.	0.800	0.732	0.774	0.810	0.933	0.891	1.000	0.720	0.872	0.750	0.842	0.867	0.790	0.867	1.000	0.476
F_{IS}	0.071	0.087	0.087	0.123	-0.080	-0.023	-0.333	0.146	-0.058	0.000	0.041	-0.087	0.121	0.001	-0.333	0.024
Sig.				***				*			*		*			

Central California

P-53	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	43	41	39	21	16	64	6	25	39	8	115	16	68	102	15	23
150	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.022
161	0.023	-	-	-	0.031	-	-	-	-	-	-	-	0.007	-	-	-
163	-	-	-	-	-	-	-	-	-	-	0.017	-	0.022	0.025	0.100	-
165	-	-	-	-	-	0.016	-	-	-	-	0.004	-	-	-	-	-
167	-	-	-	-	-	-	-	-	-	-	-	0.219	-	0.010	-	-
169	0.326	0.293	0.244	0.262	0.375	0.172	0.250	0.120	0.141	-	0.291	0.188	0.257	0.324	0.233	0.130
171	0.163	0.073	0.103	0.048	0.094	0.188	-	-	-	0.188	0.170	-	0.029	0.074	0.133	0.196
173	-	-	-	-	-	0.023	-	0.120	0.141	-	-	-	0.015	-	-	-
175	-	-	-	-	-	-	-	-	-	-	0.004	0.031	-	-	-	-
177	0.081	0.037	-	0.048	0.031	0.023	-	0.020	0.077	0.313	0.044	0.375	0.088	0.069	0.100	0.044
179	0.244	0.232	0.346	0.405	0.125	0.258	0.333	0.100	0.077	0.188	0.261	-	0.199	0.304	0.367	0.609
181	-	0.098	0.090	0.119	0.188	0.086	0.250	0.500	0.449	0.188	0.113	0.156	0.360	0.181	-	-
183	0.058	0.110	0.051	0.048	0.031	0.063	0.083	0.100	0.077	-	0.030	0.031	0.007	-	0.067	-
185	0.105	0.159	0.167	0.071	0.125	0.172	0.083	0.040	0.039	0.125	0.065	-	0.015	0.015	-	-
191	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.786	0.807	0.772	0.742	0.781	0.827	0.750	0.699	0.740	0.781	0.798	0.750	0.755	0.759	0.769	0.572
H obs.	0.814	0.854	0.795	0.905	0.625	0.781	1.000	0.800	0.718	1.000	0.791	0.625	0.779	0.735	0.667	0.609
F_{IS}	-0.023	-0.045	-0.017	-0.197	0.231	0.063	-0.250	-0.124	0.042	-0.217	0.013	0.198	-0.025	0.036	0.167	-0.042
Sig.					*								*	*		

Oki-1	PUDY98	NOYA97	NOYA99	ALBA98	ALBY98	RRHA	RRGVY97	RRGVY98a	RRGVY98b	RRGVY00	LAG	LSGAY98	OLEA96	OLEA9798	RWMA97	RWMY98
(N)	39	42	42	20	16	62	5	25	39	6	101	16	64	106	13	23
88	-	-	-	-	-	-	-	-	-	-	0.020	-	-	0.005	0.039	-
92	0.064	-	-	-	-	0.016	-	0.260	0.205	-	0.005	-	-	0.014	0.039	0.152
96	0.039	0.083	0.095	0.025	-	0.210	0.200	0.160	0.167	-	0.064	0.125	0.031	0.047	0.192	0.087
100	0.013	0.060	0.107	0.025	0.094	0.105	-	0.080	0.090	0.167	0.109	0.031	0.063	0.028	0.154	-
104	-	0.024	0.012	0.025	0.031	0.024	-	-	-	-	0.045	-	0.063	0.076	-	0.044
108	-	-	-	-	0.094	-	-	-	-	-	-	-	-	-	-	-
112	0.205	0.107	0.143	0.275	0.063	0.153	-	0.080	0.205	-	0.228	0.188	0.359	0.269	0.192	0.196
116	0.039	0.131	0.143	0.075	0.188	0.097	0.200	0.200	0.180	0.250	0.064	0.156	0.023	0.071	-	-
120	-	-	-	-	-	-	-	-	-	-	-	-	0.039	0.009	-	-
124	0.077	0.107	0.214	0.150	0.063	0.081	0.300	0.080	0.064	-	0.114	0.094	0.180	0.264	0.192	0.304
128	0.154	0.333	0.179	0.150	0.313	0.210	-	0.120	0.051	0.333	0.233	0.313	0.180	0.146	0.154	0.109
130	-	-	-	-	-	-	-	-	0.013	-	-	-	-	-	-	-
132	0.115	0.155	0.083	0.250	0.094	0.081	0.300	0.020	-	-	0.079	0.031	0.047	0.038	0.039	0.109
136	0.295	-	0.024	0.025	0.063	0.024	-	-	0.026	0.250	0.030	0.063	0.016	0.033	-	-
140	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
144	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
148	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
152	-	-	-	-	-	-	-	-	-	-	0.010	-	-	-	-	-
160	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
H exp.	0.821	0.814	0.853	0.809	0.828	0.854	0.740	0.833	0.840	0.736	0.851	0.813	0.793	0.820	0.837	0.813
H obs.	0.744	0.786	0.714	0.700	0.625	0.807	0.600	0.880	0.872	0.833	0.891	1.000	0.734	0.802	1.000	0.826
F_{IS}	0.107	0.047	0.174	0.160	0.275	0.064	0.294	-0.036	-0.025	-0.042	-0.042	-0.200	0.082	0.027	-0.156	0.006
Sig.		*	*		**		**			*		*	*	*		

APPENDIX 2. UCD-BML-SCWA ARCIMS GIS PROJECT

The enclosed CDrom contains sample data, programming code and scripted batch files, for the ArcIMS website: http://sonoma.regis.berkeley.edu/website/bml/salmon. With the exception of the ESRI software and the Windows 2000 Server operating system, all software is available free of charge from the sources listed below. Information about ArcIMS licensing can be obtained from the URL http://www.esri.com. ESRI's ArcView and ArcGIS software packages were also used for pre-processing the geographic data.

We expect and encourage ArcIMS developers to incorporate, borrow and/or modify the methods described here if they are found to be useful.

NOTE: This site may be moved and linked to the following URL at sometime in the near future: http://www.bml.ucdavis.edu

Computing Environment and System Requirements

The software needed to install and run this site includes:

- ESRI ArcIMS 3.1
- Microsoft IIS-Internet Information Server (or Apache 2.0.4 webserver)
- Jakarta-Tomcat 4.0 servlet engine (http://jakarta.apache.org/)
- ActiveState ActivePerl 5.6, PERL programming tools (http://www.activestate.com/)
- gen2shp.exe (a software utility to create a shapefile(tm) from a text file). "gen2shp.exe" is a third-party GNU general public license utility. Un-compiled C source code and additional information can be found at the URL http://www.intevation.de/~jan/gen2shp
- jsImagePlayer (a software utility available at http://sgi.felk.cvut.cz/~xholecko/)

The ArcIMS 3.1 GIS data and processing scripts were designed to run on a Windows 2000 or XP server. Contact ESRI for questions regarding installations using alternative operating systems.

Sample Data Layers Enclosed

Samples of the following data layers and the ArcIMS directory structure are included on the enclosed data disk. Many of the raster layers (e.g. 1m DOQQs and DRGs) on the ArcIMS server are very large files. DOQQs for 7.5 minute quads are ~ 160MB in raw form, for example. Smaller subset samples of each data type were included in order to fit a representative sample on a single CDrom. Data layers used in the GIS include:

Live Data

- CODAR ocean surface current measurements (1,200 sq. mile coverage off Marin and Sonoma Counties)
- NOAA Data Buoy Center buoy locations and live-links for central and northern California
- CDEC (California Data Exchange Center) stream monitoring and real-time live-links for the Sonoma and Marin County area
- USGS stream flow gauge locations and real time live-links for the Sonoma and Marin County area

Marine/Stream

- Bathymetry-(10m contours) for northern California coast from 10-600m
- California watershed boundaries, three levels of aggregation
- Marin County streams
- Olema Creek segmented layer with linked sample data (provided as proof-of-concept)

Political/Governmental

- County boundaries and names
- Major roads

Raster/Image Data

- USGS DOQQ samples at 1m and 2m resolution (Digital orthographic quarter-quads, i.e. geo-referenced aerial photographs)
- USGS DRG samples at 1:24K, 1:100K, 1:250K depending on level of zoom (Digital Raster Graphics, i.e. digital topographic maps)

- Shaded relief layer

Salmon Related

- Coho salmon hatchery locations for northern California
- Coho salmon ESU (for Central California)
- Lagunitas Creek coho spawning sites (J. Watters study)

Description of Custom PERL Scripts and CODAR Data Processing

The following scripts are used for processing the real-time CODAR data:

- *codar.bat*
- *ftp_codar_win2k.pl*
- *process_codar_win2k.pl*
- *gen2shp.exe*
- *cleanup_codar_win2k.pl*

Hourly real-time Total Vector Files are incorporated as data layers into the GIS browser. The 24-hour animation tool is linked to the metadata panel on the bottom of the GIS browser window. The direct link to the CODAR animation tool is: http://sonoma.regis.berkeley.edu/website/bml/codar/animation/jplay.html

CODAR data is processed as follows:
The batch file *codar.bat* runs every hour as a Windows 2000 "scheduled task". This requires PERL (ActiveState) with CPAN PERL Modules: Net::FTP, Time:ParseDate, Date::Manip and the GNU licensed utility *gen2shp.exe* to be installed.

The batch file first executes *ftp_codar_win2k.pl* which ftp's the BML CODAR server, figures out what the 24 most recent CODAR files are and downloads those that are not already on the ArcIMS server. It then determines the most recent Total Vector File and jpeg picture file and downloads those that are not already on the local system (this is a check against those periods when the FTP server is down, otherwise only the latest file would be needed). It then determines the name of the most recent jpg and TVF files, and copies these to files named *codar_tvf_latest.txt* and codar_jpg_latest.jpg. It also makes the **codar.js** file, which is used in the ArcIMS layer list to correctly label the shapefile(tm) with the current date and time.
(Note: CODAR servers are not publicly accessible and require that an ftp account be established for successful login).

The batch file then executes *process_codar_win2k.pl* that converts the CODAR ASCII Total Vector File to an arcgenerate text file (a proprietary format compatible with ESRI GIS software). The execution of *gen2shp.exe* creates the CODAR vector shapefile(tm) layer in the GIS.

The final batch process is execution of *cleanup_codar_win2k.pl* which removes temporary files and files used for creation of the preceding sample. This script creates sorted lists of the latest CODAR jpg and TVF files on the file system, uses the copy command to create the CODAR animation jpg files from the 24 most recent jpg files (named codar1.jpg to codar24.jpg) and then deletes all but the 24 most recent CODAR jpg and Total Vector Files.

The CODAR animation is displayed using a simple Javascript(tm) tool, *jsImagePlayer*, so that it can be run in most web browsers without the user needing to download a plug-in.

Description and Processing of Live-link Data Sources

The following text describes how the live web-based data sources were incorporated into the ArcIMS site:

Example 1:

NOAA Data Buoy Center (NDBC)
URL http://www.ndbc.noaa.gov/

The NDBC develops, operates, and maintains a network of buoy and C-MAN stations.